



The NASA Heliophysics Virtual Wave Observatory

A Portal for Searching and Accessing Heliophysics Wave Data

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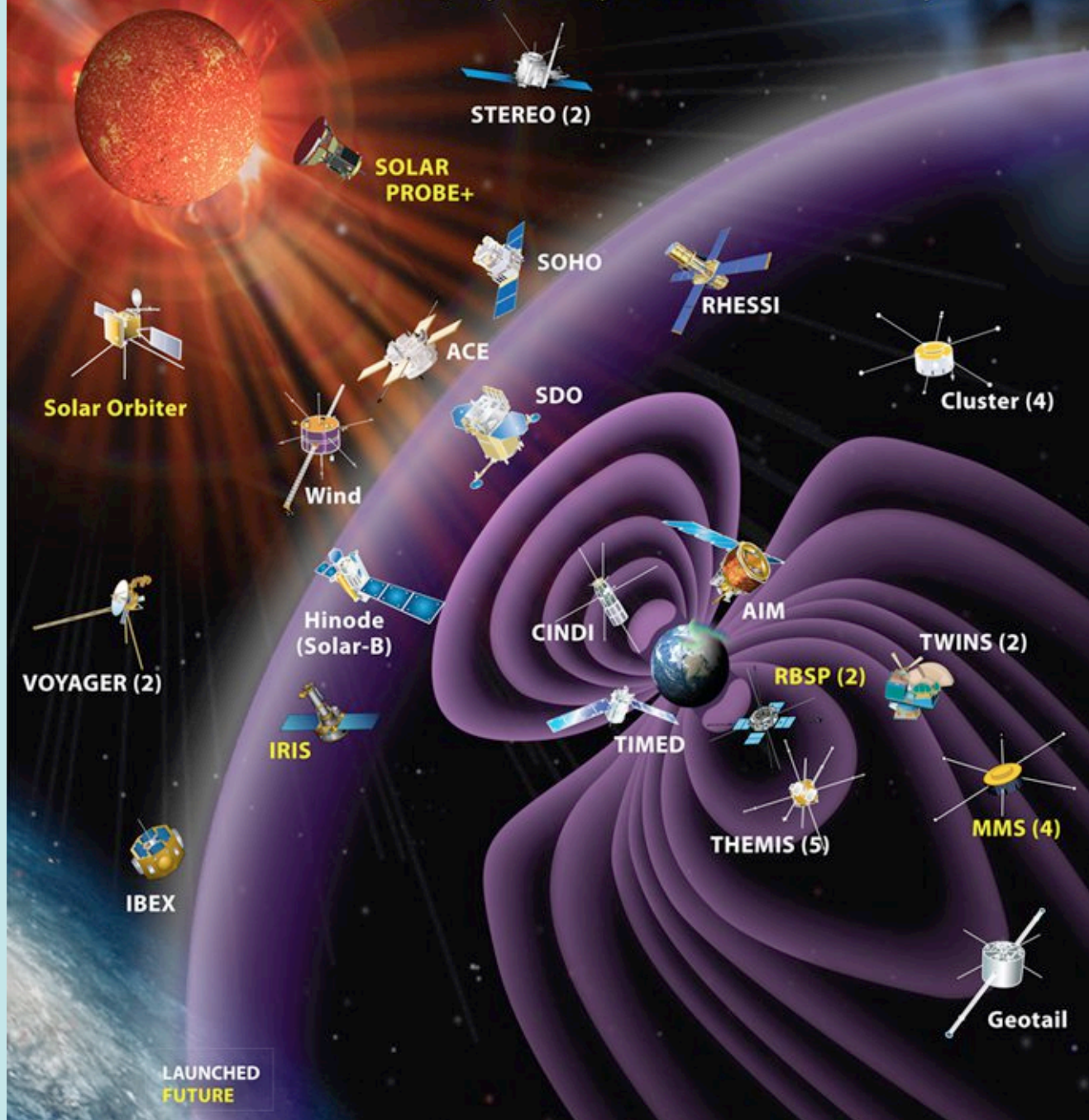
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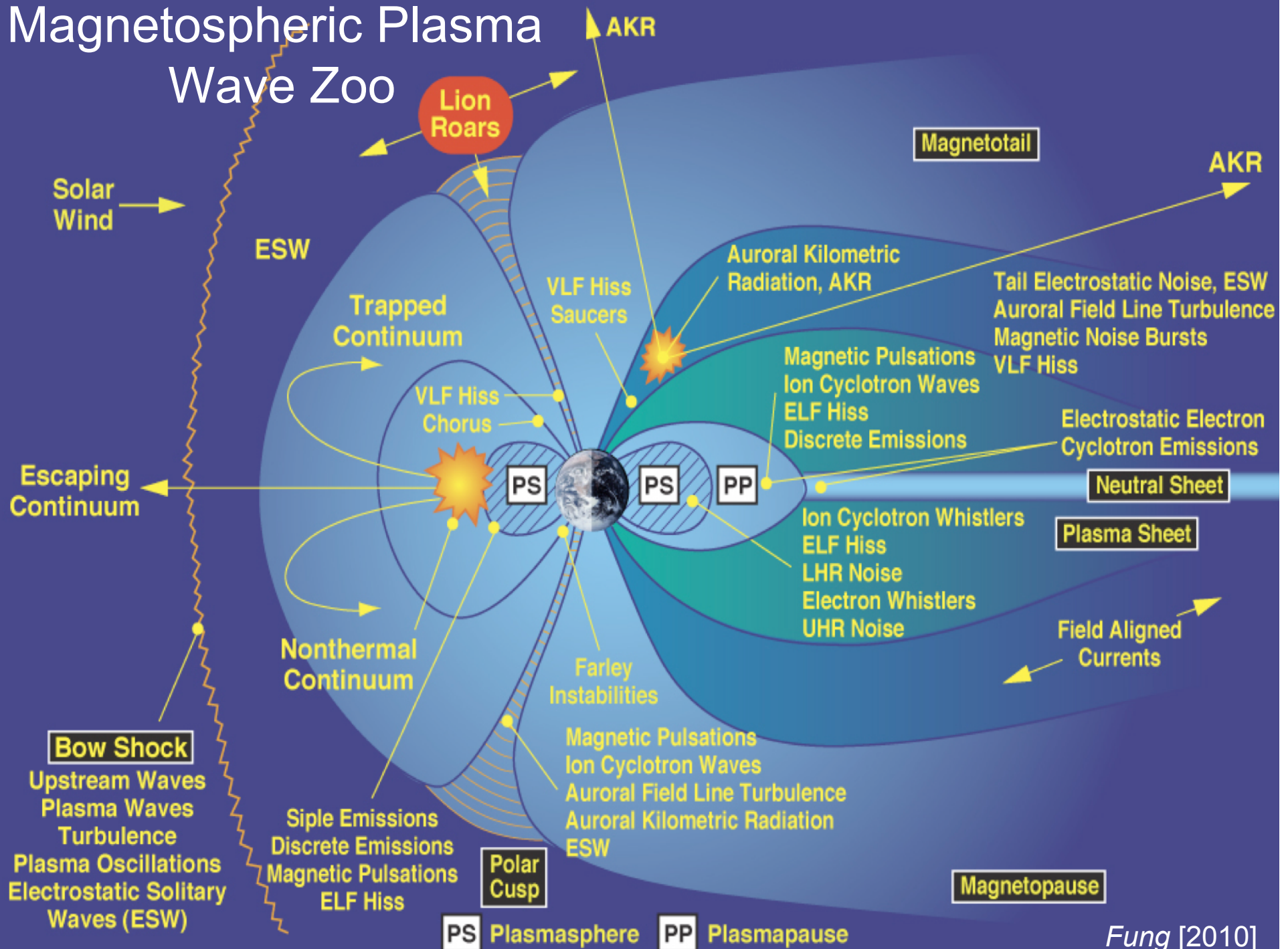
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Presented at the CAWSES-II Symposium, Nagoya, Japan, November 18-22, 2013

Evolving Heliophysics System Observatory



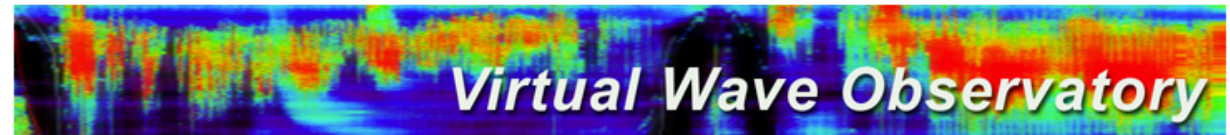
Magnetospheric Plasma Wave Zoo



The VWO

A component of the NASA *Heliophysics Data and Model Consortium (HDMC)* that:

- Focuses on serving heliophysics wave data, enabling *searchability*, *understandability*, and *usability* of all (online-accessible, distributed) heliophysics wave data
- Covers all heliophysics domains
 - Waves are everywhere
 - VWO supports all heliophysics disciplines
- Is “**SPASE** inside” for
 - Data set registration
 - Data querying



Virtual Wave Observatory

+ Home

Virtual Wave Observatory

+ Data Query

+ Tutorials

+ Education

+ Annotation Service

+ Event Lists, Products and Tools

+ VWO Data Resources

+ Registered Data Inventory

+ Data Registration Plan

Other Heliophysics Data Links

Virtual Observatories

+ VSO - Solar
+ VHO - Heliospheric
+ VEPO - Energetic Particles

+ VMO - Magnetospheric (NASA/GSFC)
+ VMO - Magnetospheric (UCLA)
+ ViRBO - Radiation Belts
+ VITMO - Ionosphere Thermosphere Mesosphere
+ VMR - Modeling Repository

Data and Information Sources

+ SPDF
+ CDASWeb

The VWO vision is to enable sharing of Heliophysics wave data and expert knowledge. The goal of VWO is therefore to make Heliophysics wave data searchable, understandable and usable by the scientific community.

Over 3.8 million wave data files are accessible from VWO.

VWO Services

Data Query

The methods you can use to find data.

Tutorial

A Primer on the use of wave data in Heliophysics research and examples of the VWO in action.

Education

The different kinds of waves in the Heliosphere: Where they are, what they are like, and what we can learn from them.

Annotation Service

Wave emissions don't come with labels. Here is where we add them.

Data Providers

How to register your data to make it searchable through the VWO.

Related Sites

SPASE - Space Physics Archive Search and Extract

Heliophysics Data Environment

Wave Research Resources

Research Groups

+ Iowa Radio and Plasma Wave Group
+ U. Maryland/IPST Space & Upper Atmospheric Physics Group
+ Stanford VLF Group
+ Swedish Institute of Space Physics, Uppsala (IRFU) Wave Group

Information

+ SEVEM
+ VERSIM

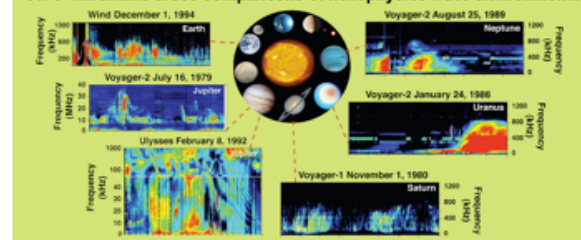
Facilities

+ Arecibo Observatory
+ Center for Atmospheric Research UMass-Lowell
+ EISCAT
+ HAARP
+ Jicamarca Radio Observatory
+ MIT Millstone Hill Observatory
+ Sondrestrom Research Facility

Professional Societies

+ URSI
+ AGU
+ PRE
+ MOP
+ APS/PPD
+ COSPAR

VWO will enable cross-comparisons of heliophysics wave environments



<http://vwo.nasa.gov>

Query Builder

- Main data query/search interface
- Traditional searches by
 - Time
 - Platform (ground/space-based)
 - Instrument
- Higher order searches by
 - Magnetospheric state
 - Observing platform locations
 - Keywords/annotation (TBD)
- Query conditions summary
- Intersection times
- Run Query to activate data search through remote data repositories and return data files or metadata files

[+ Home](#)

VWO Query Builder

[Data Source Selection](#)

[Magnetospheric State](#)

[Location](#)

[Keywords](#)

TIME: [Reset](#)
 2001-01-01T00:00:00.000Z
 2001-01-02T00:00:00.000Z
SOURCES: [Reset](#)
 # of Observatories: 0
 # of Instruments: 0
 # of Products: 0
[View Sources](#)

[View Intersection Times](#)

[Run Query](#)

VWO Query Builder

version: 3.0

Restrict your query to the following available Data Sources then press **Apply This Condition** button

Double click on a data source element to view its metadata.

[Apply The Following Conditions](#)

[Reset](#)

Time Range

Start: 2001-01-01T00:00:00.000Z = Stop: 2001-01-02T00:00:00.000Z [+ Events](#)
 -1 day | -1 hr | +1 hr | +1 day -1 day | -1 hr | +1 hr | +1 day

Measurement Type

☐ Passive ☒ AC Electric Antenna ☒ Ground-based
☒ Active ☒ AC Magnetic Antenna ☒ Space-based
☐ Frequency Range - From: 0 To: 0 kHz

[Select Active Instrument Attributes](#)

Data Set Selection

[VWO](#) [VHO](#) [VMO](#) [VSO](#) [VIRBO](#) [VITMO](#) [VMR](#)

Observatory

Dynamics Explorer 1
 FAST
 GIRO
 Galileo
 Geotail
 Hawkeye
 IMAGE
 ISEE 3
 ISIS-1
 ISIS-2

Instrument

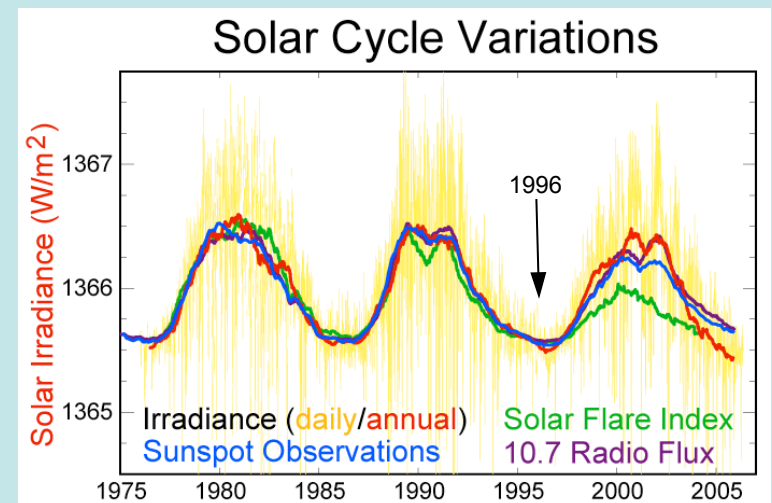
GIRO
 Ionospheric Sounder
 Galileo
 Geotail
 Hawkeye
 IMAGE
 Radio Plasma Imager (RPI)
 ISEE 3
 ISIS-1
 ISIS-2

Data Product

Cluster WHISPER Combined Daily Dynamic Spectrograms
GIRO Ionospheric Sounder
 Doppler Skymap Plots
 Ionogram Plots
 Ionogram-derived Ionospheric Characteristics
IMAGE Radio Plasma Imager (RPI)
 RPI Plasmagram Data in CDF
 RPI Plasmagram Plots
Ulysses Unified Radio and Plasma Waves (URAP)
 URAP Radio Astronomy Instrument electric field intensities 144-second Data

Example 1: Studying AKR with multi-mission data

- Study the auroral kilometric radiation (AKR) during a **solar minimum** using *Akebono*, *Geotail*, *Polar*, and *Wind* data
- Data from all satellites are available in 1996, e.g., April 1-15, 1996.
- Search for AKR observations by satellite at different locations, such as:
 - *Akebono* in the northern hemisphere & on the night side
 - *Polar* in the northern hemisphere



[from http://en.wikipedia.org/wiki/Solar_cycle]

Exercising location search:

Akebono

$20 < \text{Lat (GSM)} < 80$,
 $90 < \text{Long (GSM)} < 270$,

Polar

$70 < \text{Lat (GSM)} < 90$

“View Intersection Times”

Press “Run Query” to
execute data search

The screenshot shows the VWO Query Builder interface. Red arrows point from the text on the left to the following elements in the interface:

- An arrow points from "Akebono" to the "Location" button in the left sidebar.
- An arrow points from the Akebono search criteria ($20 < \text{Lat (GSM)} < 80$, $90 < \text{Long (GSM)} < 270$) to the "LOCATION: Reset" button and the "Akebono (113 total)" section.
- An arrow points from the Polar search criteria ($70 < \text{Lat (GSM)} < 90$) to the "Polar (19 total)" section.
- An arrow points from "View Intersection Times" to the "View Intersection Times" button.
- An arrow points from "Press 'Run Query' to execute data search" to the "Run Query" button.

VWO Query Builder

version: 3.0

SSC Satellite Orbit Data as of 2013 January 16 21:15:20

Only displaying satellite data with overlapping times from your chosen time interval

Satellite Orbit Location Query for Wave Data

Select among the following options to continue with the location search.

Satellites that are grey are available, but not for your chosen time range.

This Location Search Web Service is powered by the NASA SPDF/SSCWeb.

Satellite(s)	Coordinate System	Other Options
FAST Freja CCOM-W1 Genesis Geotail GMS-3 GOES-10 GOES-11 GOES-12 GOES-13 GOES-14 GOES-15 GOES-6 GOES-7 GOES-8 GOES-9	GSM	<input type="checkbox"/> Radial Distance <input type="checkbox"/> B Field Strength <input type="checkbox"/> Dipole L Value <input type="checkbox"/> Dipole Invariant Latitude

Below is a list of each satellite, followed by filter options chosen from the above form. Please enter filter information for each satellite, if desired, and then click the "Apply Orbit Constraints" button to fetch your requested time intervals.

Apply Orbit Constraints

Satellite	Akebono
Apply Orbit Constraints	
Filter Options	
GSM	
X	Min <input type="text"/> Re Max <input type="text"/> Re
Y	Min <input type="text"/> Re Max <input type="text"/> Re
Z	Min <input type="text"/> Re Max <input type="text"/> Re
Lat.	Min 20 deg Max 80 deg
Long.	Min 90 deg Max 270 deg

[+ Home](#)

VWO Query Builder

Data Source Selection

Magnetospheric State

Location

Keywords

TIME:

1996-04-01T00:00:00.000Z
1996-04-15T00:00:00.000Z

LOCATION:

Polar (19 total)

gsm
LAT: (70 - 90)

Akebono (113 total)

gsm
LAT: (20 - 80)
LON: (90 - 270)
of Time Intervals: 40

SOURCES:

of Observatories: 4
of Instruments: 5
of Products: 8

VWO Query Builder

version: 3.0

Instrument: Akebono Plasma Wave Observation and Sounder Experiments (PWS)

Instrument: Geotail Plasma Wave Investigation (PWI)

Instrument: POLAR Plasma Waves Investigation (PWI)

Instrument: POLAR Ultraviolet Imager (UVI)

Instrument: WIND Plasma and Radio Waves

The data products requested through the VWO include data from:

- Akebono/PWS
- Geotail/PWI
- Polar/PWI
- Wind/Waves
- Polar/UVI (from VMO)

[+ Home](#)

VWO Query Builder

Data Source Selection

Magnetospheric State

Location

Keywords

TIME:

1996-04-01T00:00:00.000Z
1996-04-15T00:00:00.000Z

LOCATION:

Akebono (113 total)

gsm
LAT: (20 - 80)
LON: (90 - 270)
Polar (19 total)

gsm
LAT: (70 - 90)
of Time Intervals: 18

SOURCES:

of Observatories: 4
of Instruments: 4
of Products: 12

VWO Query Builder

version: 3.0

Instrument: Akebono Plasma Wave Observation and Sounder Experiments (PWS)

Product: Akebono PWS Natural Plasma Wave Electric Field High Resolution Data (18 returns) (a CDAWeb service)

Time Span: 1996-04-02T02:36:00Z - 1996-04-02T03:31:00Z
Datafile: ak_h1_pws_19960402_v01.cdf

Time Span: 1996-04-02T20:09:00Z - 1996-04-02T21:44:00Z
Datafile: ak_h1_pws_19960402_v01.cdf

Time Span: 1996-04-03T14:15:00Z - 1996-04-03T15:57:00Z
Datafile: ak_h1_pws_19960403_v01.cdf

Time Span: 1996-04-04T07:51:00Z - 1996-04-04T10:05:00Z
Datafile: ak_h1_pws_19960404_v01.cdf

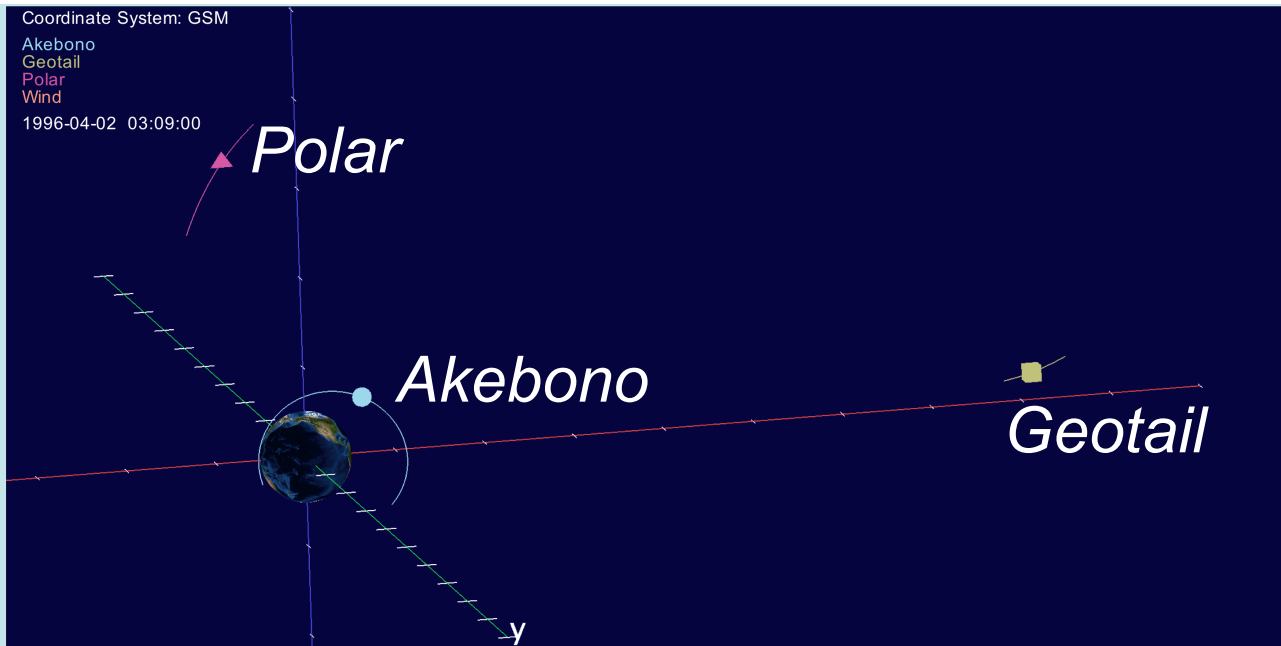
Time Span: 1996-04-05T00:51:00Z - 1996-04-05T01:20:00Z
Datafile: ak_h1_pws_19960405_v01.cdf

Time Span: 1996-04-05T18:24:00Z - 1996-04-05T19:32:00Z
Datafile: ak_h1_pws_19960405_v01.cdf

Time Span: 1996-04-06T12:42:00Z - 1996-04-06T13:41:00Z
Datafile: ak_h1_pws_19960406_v01.cdf

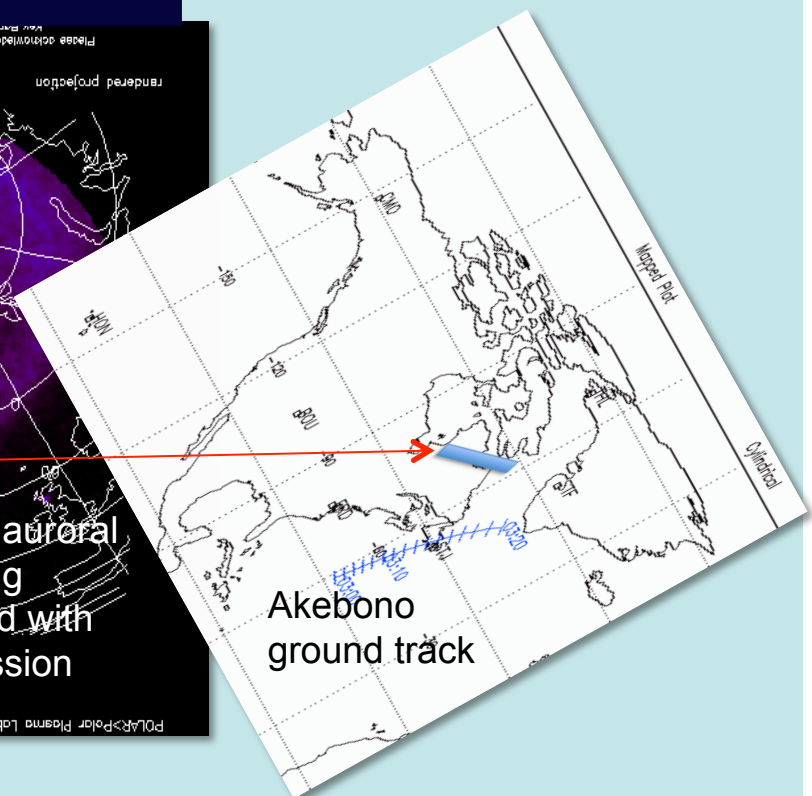
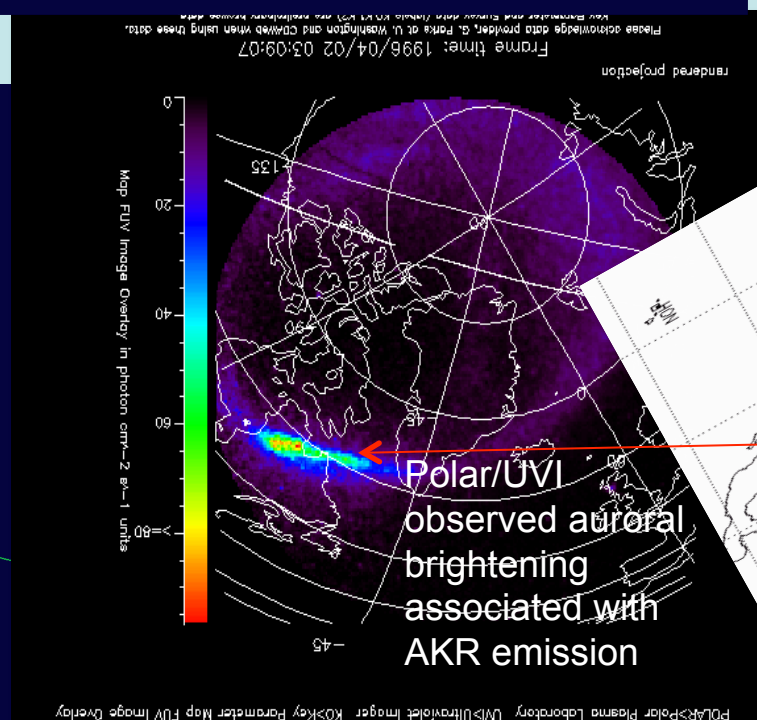
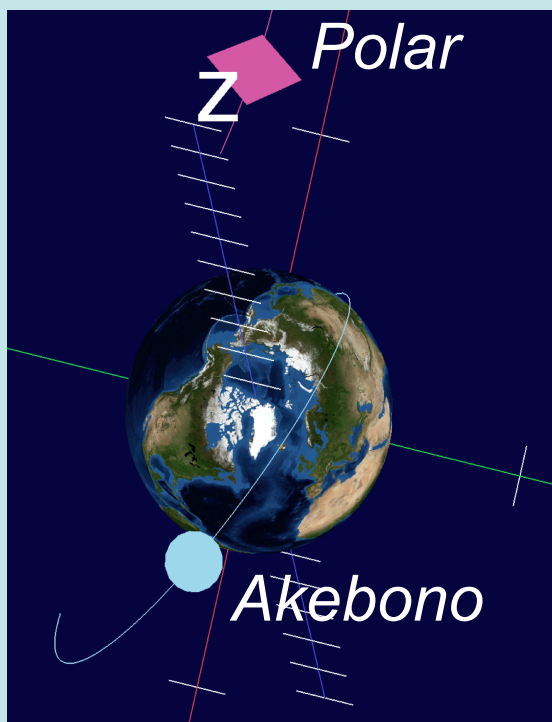
Digital / Display data

Plots by "Autoplot"



Akebono, Polar, Geotail, and Wind (not shown) in the “same” meridional plane

Akebono & Polar moving northward, Geotail moving inward near the equator



Satellite @ 3:12 UT	GSM Lat	GSM Long	Rad. Dist
Akebono (night)	49.3	175.3	1.74
Polar (day)	76.0	9.34	7.03
Geotal (night)	2.57	177.8	16.1
Wind (day)	-1.31	355.2	69.3



All satellites in
nearly the same
meridian plane

Akebono (200-4000 kHz)

300 kHz

AKR?

Polar (100-800 kHz)

300 kHz

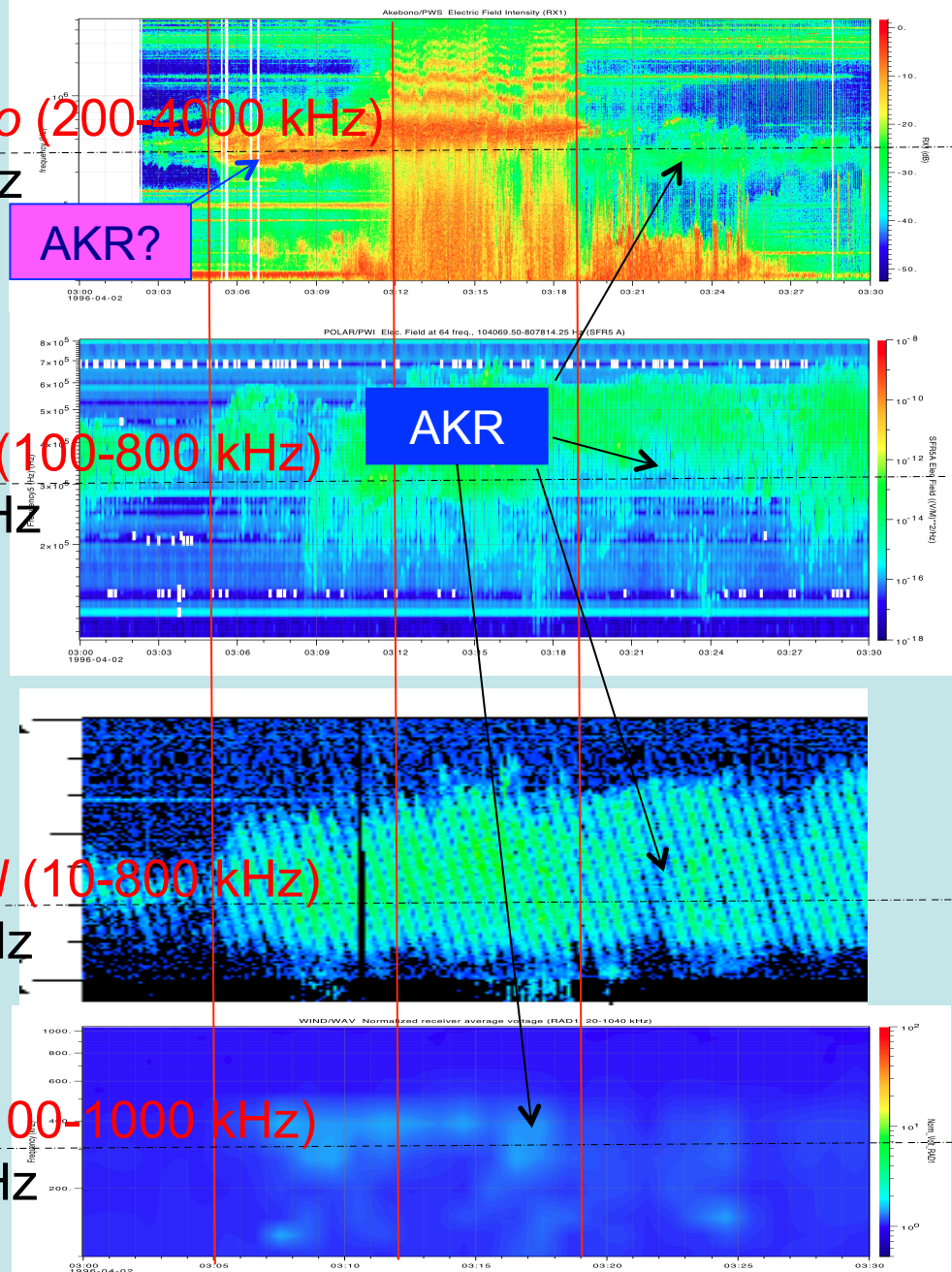
AKR

Geotail (10-800 kHz)

300 kHz

Wind (100-1000 kHz)

300 kHz



UT: 0300

3:05-3:19

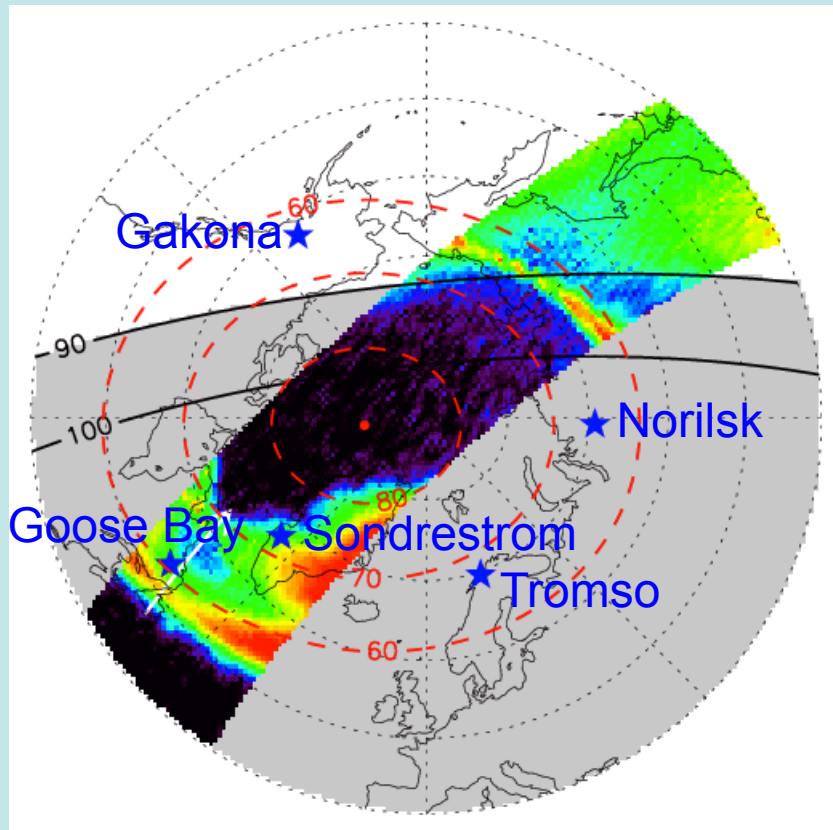
0330

Example 2: Validating FUV-Derived Auroral E-Region Electron Densities with Ionosonde Measurements

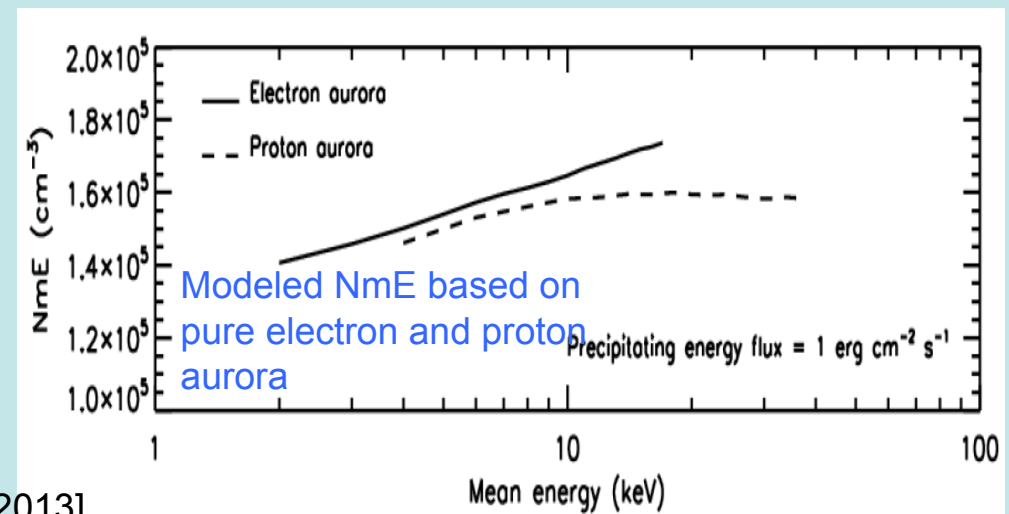
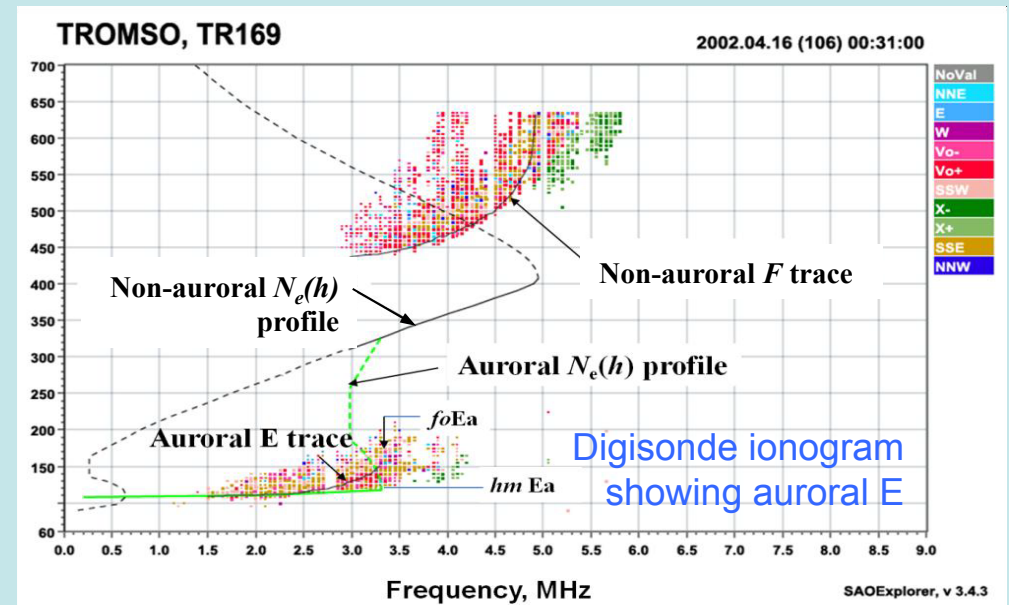
- Auroral FUV imaging observations, e.g., by the DMSP/SSUSI, can yield auroral E-region electron density information (N_mE_a , h_mE_a).
- The density information and models used to derive them can be validated by vertical density profiles measured by ground ionosondes during conjunction intervals.

Using VWO to search for Digisonde & FUV Conjunction Observations

Horizon-to-horizon SSUSI FUV scan
from DMSP F16
Nov 7, 2004 23:00UT



Blue stars: Digisonde locations in the oval



[Courtesy of H. Knight, Computational Physics, Inc., 2013]

Example 3: Investigating Low-Latitude Topside Ionospheric Sounder Observations During Geomagnetic Storms

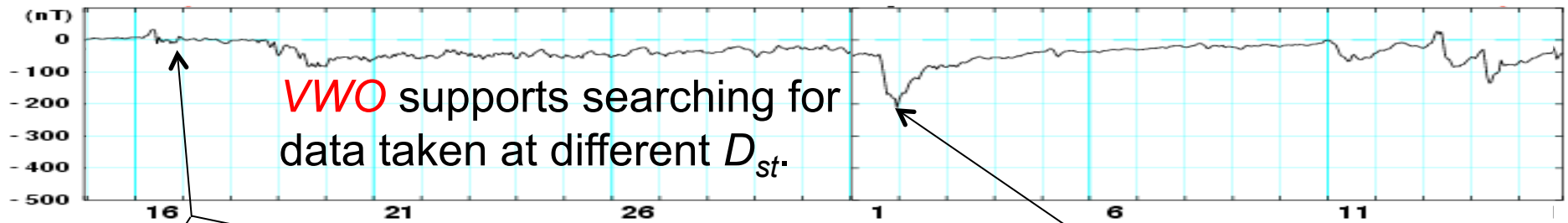
- Energetic electrons (> 30 keV) have been observed to penetrate to low-latitude topside ionosphere during geomagnetic storms.
- Equatorial precipitating particles can generate Z-mode emissions ($f_Z < f < f_T$) [Benson, AGU, 1991].
- Investigating Z-mode emissions in equatorial ionosphere (< 2000 Km) can help understand particle penetration at low latitudes.

Near-Equatorial ISIS Ionograms ~1400 km

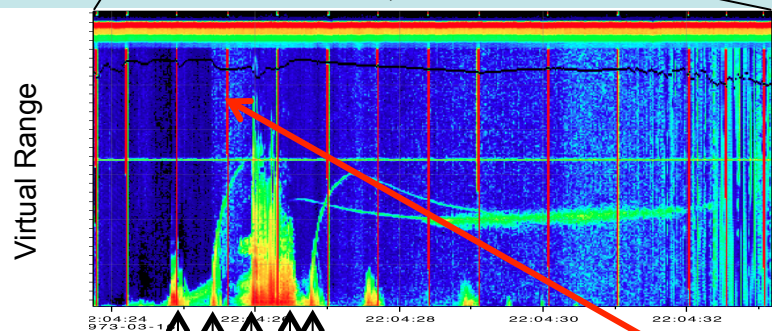
WDC for Geomagnetism, Kyoto

Dst (Final)

March 15 – April 15, 1973



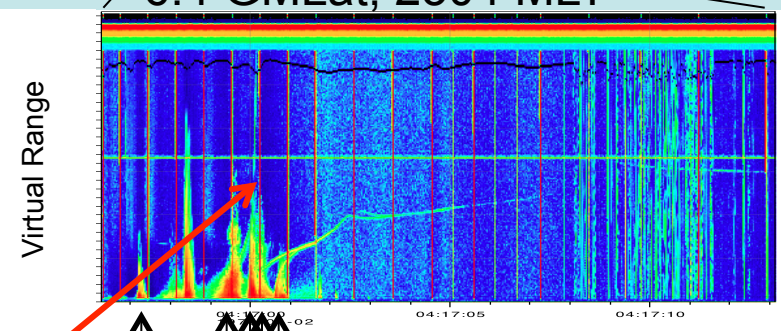
-7.4 GMLat, 0014 MLT



f_H
 f_Z
 f_N
 f_T
 f_X

Sounder
on

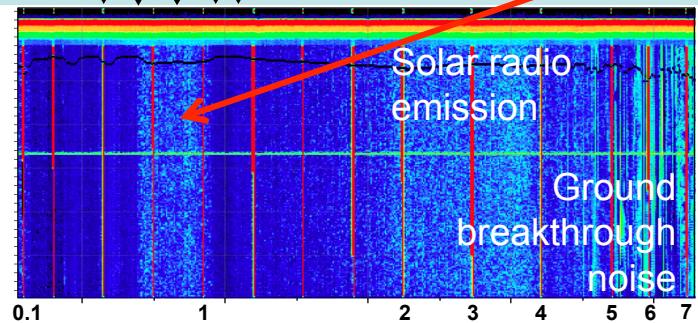
-6.4 GMLat, 2304 MLT



f_H
 f_Z
 f_N
 f_T
 f_X

Z-mode emissions
($f_Z < f < f_T$)

Time Delay

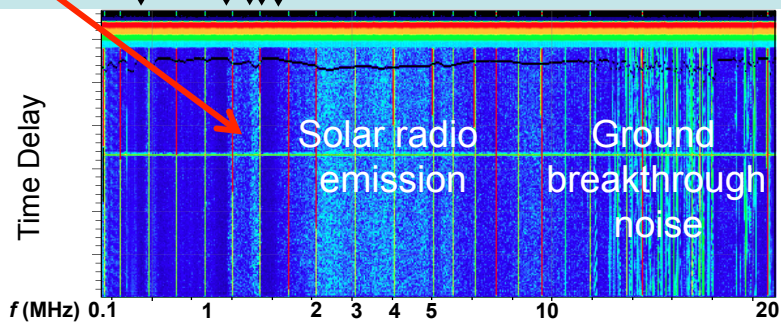


Solar radio
emission

Ground
breakthrough
noise

Receiver
only

Time Delay



Solar radio
emission

Ground
breakthrough
noise

Summary

- The *NASA Virtual Wave Observatory* (VWO; <<http://vwo.nasa.gov>>) serves the world-wide, multi-disciplinary heliophysics community.
- Using SPASE and SPASEQL technology, VWO can **search**, **access** and **display** *online-accessible (distributed)* heliophysics wave data and other VxO-accessible data.
- As shown by use examples, the *VWO can support science-based data searches* (time, platform, magnetospheric state, location).
- *VWO welcomes* your contributions to the growth of the metadata database and your feedback.
- The VWO can support *eScience* endeavors.

Backups

Search by Magnetospheric State Conditions

For a given time interval,
a user can specify
additional data-query
conditons:

- Solar activity
- Solar wind/IMF
parameters
- Geomagnetic
conditions

Magnetospheric Conditions

The Magnetospheric States are currently available for the date range:
(1970-01-01T00:00:00.00Z - 2012-12-31T23:59:59.99Z)

Apply The Following Conditions

Solar Activity Parameters:				
<input type="checkbox"/> R (Sunspot Number)	Min 0	Max 500	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> F10.7 Flux	Min 0	Max 500	Delay (Hr) 0	Ave. over (Hr) 1

Solar Wind Parameters:				
<input type="checkbox"/> Bx (GSM), nT	Min -100	Max 100	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> By (GSM), nT	Min -100	Max 100	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Bz (GSM), nT	Min -100	Max 100	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Bmag (GSM), nT	Min 0	Max 150	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Proton Temp., K	Min 0	Max 10000000	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Proton Density, /cc	Min 0	Max 200	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Velocity, km/sec	Min 0	Max 2000	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Flow Pressure, nPa	Min 0	Max 100	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Electric Field, mV/m	Min -100	Max 100	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Plasma Beta	Min 0	Max 500	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Quasi Invariant	Min 0	Max 10	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Mach Number	Min 0	Max 500	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Alfven Mach Number	Min 0	Max 500	Delay (Hr) 0	Ave. over (Hr) 1

Geomagnetic Indices:				
<input type="checkbox"/> Kp	Min 0.0	Max 9.7	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> Dst, nT	Min -1000	Max 100	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> AE (hourly), nT	Min -1000	Max 5000	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> AL (hourly), nT	Min -5000	Max 5000	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> AU (hourly), nT	Min -1000	Max 5000	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> AP Index, nT	Min 0	Max 500	Delay (Hr) 0	Ave. over (Hr) 1
<input type="checkbox"/> PC(N) Index	Min -10	Max 100	Delay (Hr) 0	Ave. over (Hr) 1

Search by Spacecraft Locations

- Location search is powered by the NASA Satellite Situation Center
- Data search based on observing spacecraft locations, local magnetic field strengths, L values, or Invariant latitudes.

VWO Query Builder

version: 3.0

SSC Satellite Orbit Data as of 2013 January 16 21:15:20

Only displaying satellite data with overlapping times from your chosen time interval

Satellite Orbit Location Query for Wave Data

Select among the following options to continue with the location search.

Satellites that are grey are available, but not for your chosen time range.

This Location Search Web Service is powered by the NASA SPDF/SSCWeb.

Satellite(s)	Coordinate System	Other Options
<div> RBSP-A RBSP-A Test RBSP-B RBSP-B Test Reimei RHESSI ROCSAT1 Rosetta SAMPEX SCATHA SNOE SOHO Sputnik 1 STS-A STS-B </div>	<div>GSM</div>	<input checked="" type="checkbox"/> Radial Distance <input checked="" type="checkbox"/> B Field Strength <input checked="" type="checkbox"/> Dipole L Value <input checked="" type="checkbox"/> Dipole Invariant Latitude

Below is a list of each satellite, followed by filter options chosen from the above form. Please enter filter information for each satellite, if desired, and then click the "Apply Orbit Constraints" button to fetch your requested time intervals.

Apply Orbit Constraints

Satellite

Akebono

Apply Orbit Constraints

Filter Options

GSM

X

Min

Re

Max

Re

Y

Min

Re

Max

Re

Z

Min

Re

Max

Re

Lat.

Min

deg

Max

deg

Lon.

Min

deg

Max

deg

Radial Distance

Min

km

Max

km

B Field Strength

Min

Max

Dipole L Value

Min

Max

Dipole Invariant Latitude

Min

Max